HINTS TO TRAVELLERS.

(Revised and augmented Edition.)

By Vice-Admiral Sir George Back, F.R.S., Rear-Admiral Collinson, C.B., and Francis Galton, Esq., F.R.S.

Applications are frequently made by travellers, to the Royal Geographical Society, for instructions by which they may make their labours useful to Geography.

The Council have always shown themselves disposed to pay considerable attention to such applications, when they proceed from persons who are zealously engaged in preparing themselves for arduous enterprises.

If a specific question be addressed to the Council on some particular instrument or point of equipment, they usually refer it to a Fellow of the Society whose experience might enable him to afford a satisfactory answer. But a question of a more general nature, on the best instrumental outfit for an inexperienced traveller, is of such frequent recurrence, and demands so lengthened a reply, that the Council thought proper some years ago to appoint a Committee for its full consideration. The Report of that Committee has been extensively circulated under the title of 'Hints to Travellers;' but as the first edition is nearly exhausted, we have been requested to take the opportunity of making a thorough revision of the work. This we have done. The present edition of the 'Hints to Travellers' will therefore form the answer of the Council, to whomsoever may request information, on the subject of which it treats.

The following remarks are to be understood as addressed to a person who, for the first time in his life, proposes to explore a wild country, and who asks, "What astronomical and mapping instruments, and other scientific outfit, ought I to take with me? and what are the observations for latitude and longitude on which I should chiefly rely?" To this end we give a list of instruments, books, and stationery, complete in itself, down to the minutest detail, so that an intending traveller may order his outfit at once. He would then be satisfied that he had omitted to provide himself with no object of real importance, that he had bought nothing superfluous, and that the different items corresponded together in size, in power, and in their several uses.

Lists drawn up by different travellers of experience would undoubtedly vary, for there is considerable difference in their practice; but a beginner would never do wrong, who followed to the letter the list we are about to give. His danger lies in adopting scattered hints from many sources, and starting with instruments which, though severally good, are, when considered as a set, incongruous

and incomplete; and, secondly, in trusting to the advice of observers who have little experience of the bush.

The outfit we describe would suit an explorer in any part of the world, who desired the means of bringing back as good geographical results as the earlier explorers of large tracts of land have ever yet succeeded in obtaining. And in this list, professedly compiled for an inexperienced observer, simple and well-known instruments alone find a place. We are very far indeed from thinking that instrument-makers have yet met all the wants of land travellers, but we *know* that good results may be obtained by such instruments as are to be bought from any good optician. We therefore urge a young explorer to make *these* his mainstay; and if he takes other instruments, to do so more for the purpose of testing and reporting on their performances, than of relying in entire confidence upon them. Again, it is hazardous for a man hastily preparing himself for a journey, to order new apparatus from a maker; he cannot be sure that it will be well made or ready in time, and he may have to set sail in possession of a strangely-shaped instrument—very delicate, difficult to pack—whose adjustments he has not had opportunity of mastering, and on which it is unlikely he will obtain information, after his departure; whilst, if he determines on buying a sextant, and other well-known instruments, he may make his selection out of great numbers that are always to be found on sale, and practise himself in their use, under the tuition of the officers of the ship, during the whole of his voyage from England. It is therefore our object to give a list of instruments with which we advise a traveller of little experience to provide himself, and which will be found thoroughly adequate to do his work.

It should be borne in mind that travellers can seldom attain accuracy in their observations, perhaps hurriedly made, during a first exploration. Latitude within $\frac{1}{4}$ of a mile, and longitude within $\frac{1}{4}$ of a degree, is a somewhat better result than is usually obtained.

Outfit for an Explorer.

Examination of Instruments.—Let every Instrument be tested and its errors determined and tabulated at the Kew Observatory of the British Association. This is done for a trifling fee (ordinary thermometers, 1*s.*; boiling-point thermometers, 2*s.* 6*d.*; ditto by calibration, 5*s.*; marine and portable barometers, 5*s.*; azimuth compasses, 2*s.* 6*d.*; superior sextants, 5*s.*; quadrants, &c., without telescopes, 1*s.* Unifilars, dip circles, and other magnetic instruments are also verified. The instruments should be sent *prepaid*, or taken to the "Superintendent of the Kew Observatory, Richmond." The establishment lies ten minutes' walk from the *Richmond* railway station, and is reached through a farm-yard, leading into a large meadow.

Sextant for regular work—

A sextant of six-inch radius, light in weight, by a first-rate maker, divided on platinum, to ten minutes. It must have a moveable ground-glass screen in front of the reading-off lens, to tone down a glaring light.

The handle must be large and convenient.

Sextant for detached expeditions, and for taking altitudes when the other sextant is in use for lunars—

A sextant of three-inch radius, graduated to half-degrees, in a leather case, fitted to slip on to a leather belt, worn round the waist, if required.

Mercurial Horizon—

The trough must not be less than $3\frac{1}{4}$ inches, inside length, and of the usual construction for filtering the mercury when it is poured in. The glass screen should fold, and be large enough to cover the trough without touching it. It must be by a first-rate maker, for inferior glass distorts the image. *Reserve:* one spare glass and an iron 3 or 4 ounce bottle of mercury.

Watch—

A good strong silver watch, not too heavy, with an open face and a second-hand: it must wind up at the back. The hands should be black steel, long enough to cover the divisions. The divisions should be very clear and distinct. See that the second-hand falls everywhere, truly upon the divisions. *Reserve:* at least two other watches of the same character; these should be rolled up separately, each in a loosely-wrapped parcel of dry clothes, and they will never come to harm; they should be labelled, and rarely opened. The immediate envelope should be free from fluff or dirt. Covers of chamois leather should be washed before use. Half-a-dozen spare watch-glasses, fitting easily—two to each watch. Three spare watch-keys; one might be tied to the sextant-case, one wrapped up with each watch.

Compass—

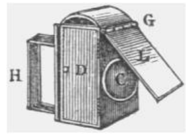
An azimuth compass, graduated from 0° to 360°, with a shield of brass cut out here and there, to admit light, fixed over the glass. *Reserve:* two spare glasses and a second azimuth compass.

Two pocket compasses, from $1\frac{1}{2}$ to 2 inches in diameter. Their needles must carry cards graduated, like those of the azimuth compass, from 0° to 360°, in addition to the points. These compasses should be light in weight, have plenty of depth, and be furnished with catches, to relieve the needle from its pivot when unused. The needles should work steadily and quickly: such as make long, slow oscillations, are to be avoided. Cards, half black and half white, are recommended for night work.

Lantern—

To be used with oil. The reflector should throw a clear light forwards and *downwards*. A good lantern is *most* important. A small ball of spare wick. Oil. Wax candles, for use on detached expeditions.

The following is a good design for a lantern :—



L. The reflector, of stout tin, moving stiffly on a good substantial brass hinge G. It must remain in whatever position it is placed.
D. The door. On opening it, the lamp is slid into its place.
C. The condensing lens.
H. The handle—a substantial one. It folds flat, and is fixed, not to the body of the lantern, but to a shield, to protect the knuckles from the heated body of the lantern. Between the shield and the lantern are the air-holes, to let in air.

Thermometers—

Three short and stout boiling-point thermometers, and a tin pot to boil them in. (*See* p. 286.)
Three ordinary thermometers, graduated to 160° at least, if for hot climates.

Aneroid—

Large pocket size (2½ inches across) capable of working without fracture over the highest mountain pass that is expected.

Mapping Instruments—

Protractors: one large circular brass one, 5 or 6 inches in diameter; 1 horn protractor, 5 inches, all graduated, like your compasses, from 0° to 360°; 2 semicircular ones, 3½.
A graduated ruler of 1 foot or more, in metal; a small square; a *small* case of instruments. 2 dozen artists' pins. Medium size measuring tape, say 12 yards; pocket ditto, 2 yards.

Memorandum.—We have designedly omitted from this list both *chronometers* and *mountain barometers,* on account of their proved difficulty of transport without injury, and the frequent disappointments they have caused, even to very careful travellers.

Additional Instruments, not necessary, but convenient.

Telescope—

A large naval or deer-stalking telescope, for observing eclipses of Jupiter's satellites and occultations of small stars. It should be fitted with a micrometer. (*See* p. 281.) The traveller should test it on the satellites, and be himself satisfied that he can see them through it, before concluding the bargain. An ordinary telescope is wholly inadequate for that purpose.

Stop-watch, or pocket chronometer.

Pedometer.

Empty barometer tubes, and an iron bottle of mercury for filling them, to be used at a few important stations. (*See* p. 285.)

Pocket level, with a mirror to show where the bubble is, when it is held to the eye.

Mountain apparatus for boiling water, as used by the Alpine Club; useful for determining the heights of windy mountain-tops.

Maxima and minima thermometers. } For meteorological observations, *see* p. 288.
Rain gauge. }

Packing.—It is difficult to give general rules, because the modes of transport vary materially in different countries. Inquiry should be made by the intending traveller at the Royal Geographical Society's rooms, as to what

would be the best for him. The corners of all the cases should be brass-bound; the fittings should be screwed, and not glued; and the instruments should admit of being taken out and replaced with perfect ease. Thermometers travel best when slipped into india-rubber tubes; and a coil of such tubing will serve as a floor, to protect a case of delicate instruments from the effects of a jar.

Stationery—

An artist's board, or at least a stiff portfolio, to rule and draw upon, as large as can conveniently be carried.

Plenty of good ordinary paper. Note-books (not "metallic," for prepared paper wants strength, and the leaves of such books are constantly torn out and lost; they are also damaged by wet). They should all be of one size, say 5 inches by 3½, or larger. A leather pouch, having a flap buttoning easily over, to hold the note-book in use.

Two (or three) ledgers of strong ruled paper, foolscap size, each with a leather binding; the pages should be numbered, and journal observations, agreements, and everything else of value, written in them.

A sheet of blotting-paper cut up and put here and there in the ledgers.

Tracing-paper, both carbonised and transparent.

Blank maps, ruled for latitude and longitude.

Plenty of brass pens and holders; also fine drawing-pens (steel crowquills) and holder. FH pencils; HB ditto.

Penknives. India-rubber cut up in bits.

Ink-powders of a kind that do not require vinegar. Red ink.

Paints for maps, viz., Indian ink, lake, cobalt, gamboge, oxgall, in a small tin case.

Half-a-dozen sable paint-brushes.

Books—

Raper's, Inman's, or Norie's Navigation Tables.

Weale's Tables are convenient from their compactness.

Shadwell's Cards of formulæ, and Carr's Synopsis, if the traveller has any mathematical knowledge.

Nautical Almanack for current and future years, strongly bound.

Three or four almanacks, such as Hannay and Dietrichsen. They give a vast deal of information, are useful to take on detached expeditions, also to cut tables out of.

Tables for boiling-point thermometers, to be got at the thermometer-maker's.

Celestial Maps (uncoloured) pasted on canvas (and learn how to use them.)

The best maps of the country you are going to visit that are to be obtained.

Admiralty Manual for the use of Travellers.

Though the sextant, almanack, and logarithmic tables taken by land travellers, are identical with those used at sea, yet the observations of the landsman and his whole method of work have quite a different character to that of the navigator. This is owing to several reasons, of which the following are the chief:—

1. A sailor is obliged to measure his altitudes from the sea horizon, and must therefore mainly depend on the sun. The landsman is obliged to measure his altitudes from the mercurial horizon, and mainly observes stars; because the double meridian altitude of the sun is frequently out of the range of his sextant, and a

mid-day halt is inconvenient. The use of stars and the mercurial horizon introduces difficulty on the one hand, and great refinement on the other.

3. At sea, the accuracy required for mapping a country is of no use; neither could the sailor attain to such accuracy, if he wished it. First, because of the uncertainty of the effects of refraction upon the apparent position of the sea horizon. Secondly, because the mercurial horizon gives a double altitude, and therefore double precision to the result; so that a sextant of 3 inches radius on land has the efficacy of one of 6 inches at sea. And, thirdly, because the unsteadiness of the ship interferes with the free use of the inverting telescope.

3. The sailor carries Greenwich time with him by means of his chronometers. A landsman cannot trust to chronometers. He must find Greenwich time by the independent means of lunars, satellites, or occultations.

4. Positions at sea that cannot be determined by astronomical observations, are roughly laid down by Course and estimated Distance from the last fixed station. On land, they can be laid down with great accuracy by triangulation.

5. The unsteadiness of the ship makes observation of the satellites, or of occultations of stars, an impossibility to sailors, while they are exceedingly easy and convenient to land travellers.

6. Magnetic variation has to be found constantly at sea, owing to the rapid change of position and the iron in the ships. On land but few observations are required.

Latitude and Longitude.

General Remarks on Observing.—Endeavour with much forethought to *balance* your observations. Whenever you have to take a star's altitude for time east, select and wait for another star as nearly as may be of the same altitude west, and use the same telescope, horizon roof, &c. If a meridian altitude be taken north, choose another star of similar altitude, and take it south, so also with lunars. In this way your observations will be in pairs, and the mean of each pair will be independent of all instrumental and refraction errors; and by comparing the means of these pairs, one with another, you will know your skill as an observer, and estimate with great certainty the accuracy that your results have reached. Never rest satisfied with your observations, unless you feel sure that you have gained means of ascertaining the limit beyond which you certainly are not wrong. Weight all your observations; that is, when you write them down, put "good," "very good," "doubtful," &c., by their sides.

Nature of Observations :—

For Latitude—

1. The meridian altitude of the sun or stars is the simplest and safest. Circum-meridian altitudes of stars in pairs, N. and S. of the zenith, afford the perfection of accuracy. It is to be understood that several altitudes should be read off, and time noted, during the 5 or 10 minutes before and after the meridian passage.

2. The altitude of the Pole Star is a ready method in the northern hemisphere, but only available with an ordinary sextant and mercurial horizon between the N. lats. of about 15° and 60°. Nearer the Equator it is too low for the mercurial horizon, and nearer the Pole it is out of the range of the sextant.

3. When the sky is partly clouded, secure whatever stars you can surely identify, in case the meridian altitudes should be lost. Almost any two stars, with the interval noted, are sufficient for the determination of the latitude, by the more or less troublesome calculations described in works on navigation. It is better to observe one or two additional stars as a check against mistake.

For Longitude—

Whenever you intend to observe for longitude, make a regular night of it; working hard and steadily, so as to accumulate a mass of observations, at a limited number of stations. Taking a few offhand observations, at a great many stations, is time thrown away.

1. No method is more serviceable than that by lunar distances.

They should be made in pairs, with stars E. and W. of moon, and nearly equidistant from it. Also the thermometer and barometer (or its equivalent, a thermometer in boiling water) should be noted, and the refraction corrected accordingly. If thermometric and barometric corrections be omitted, in observations made on a high and heated plateau, there will be serious errors in the results.

A complete pair of lunars, made wholly by one person, consists of the following observations, *in addition to those for latitude.* None of them may be omitted :—

1. Read thermometer in air.
2. Adjust horizon-glass, if necessary.
3. Two pair of observations for index error.
4. Three altitudes for time, star E.
5. Three altitudes for time, star W.
6. Five lunar distances, star E. of moon. (A)
7. Five lunar distances, star W. of moon. (A)
8. Three altitudes for time, star W. (A)
9. Three altitudes for time, star E. (A)
10. Two pair of observations for index error.
11. Read thermometer in air.
12. Read barometer (or its equivalent, as thermometer in boiling-water).

The series A may be repeated over and over again, so long as the eye and hand can be surely depended on.

2. Occultations give the longitude with great accuracy, but they rarely occur. They are very troublesome to calculate.

3. Jupiter's satellites occur somewhat more frequently than occultations. They give fair results, and are most convenient approximations to a traveller; for they require no calculation at all, except for local time.

NOTES BY FRANCIS GALTON, F.R.S.

It may save trouble to others if I mention here the way which, after many trials, I adopted of observing with a sextant. During the day time I made out a list of the stars that culminated at convenient hours, and their expected altitudes. I set my watch by sunset, if it was very wrong, and took care that the minute hand went in correspondence with the second hand; that is to say, that the minute hand was truly over a division when the second hand pointed 0 seconds. If they did not go together, I moved the minute hand till it was rightly set. Then I spread my rug north and south in an open spot of ground, trampling down the bushes and long grass round it. Next, when the time of observing approached, I lighted my lantern and set it on the ground in front of my rug; to this I brought all my instruments, and first spreading a small cloth to the right of the lantern, I set my horizon on it, filled it with mercury, and covered it with a glass. The cloth was to catch any mercury that might be spilled. I then propped up my watch to the left of the lantern, laid down my note-book, with the leaves tied open, and taking out my sextant, adjusted it to the expected altitude, and screwing on the telescope, which always was kept at my focus, I laid myself flat down on the rug. Then taking off the roof from the horizon if there happened to be no wind, and turning the glare of the lantern away from my eyes, and upon the watch, I made an accurate contact of the star with its reflected image; then looking quickly round, I observed the watch. I now turned the lantern towards me, changed hands with the sextant, read off and wrote down, then turned the lantern back on the watch and recommenced. For a meridian altitude I read off and wrote down about ten observations, both time and altitude, beginning a little before the star reached the meridian, and continuing after it had perceptibly sunk; it was thus easy to estimate the meridian altitude with accuracy. For greater refinement, in order to measure an important base line, I occasionally protracted these altitudes and drew a curved line through them with a free hand, to guide my judgment in estimating the meridian altitude. For lunars, I took time with my second sextant before beginning; also two or three times during the progress of the lunar, and finally at the close of all. I was thus very independent of the good going of my watch, for by observing every half hour, no watch that went at all could go far wrong.

Azimuth.

General Remarks.—The azimuth compass is one of a traveller's most useful instruments. To use it, it is best to make a pile of stones and lay the cover of the compass on the top, with its bottom upwards; this makes a smooth table for the azimuth compass itself to be moved about on. Be on guard against magnetic rocks; it may happen that the bare peaks of high hills, which are the best of places for observing from, and which a traveller often makes great sacrifices to reach, will be found so magnetic as to make compass observations worthless. A small sextant should always be taken up on these excursions. It is of little use in a wild country to devote much time to getting accurate bearings, as the landmarks themselves are rarely well defined: the main endeavour should be not to mistake one hill for another, to judiciously select good angles, and to carry on more than one independent scheme of triangulations at the same time, by comparison of which the accuracy of the whole may be tested. It is surprising how much work may be thrown away by want of judgment; and also how much may be done, with very little trouble, by a person who has acquired a good eye and memory of country.

For true bearing—

The true bearing of a heavenly body may be obtained either from observations of its altitude or from the apparent time. As the formula for obtaining the latter does not appear in many works on Navigation, it is given:—

Time.	Azimuth.	Month		Day		
H. M. S.	° ′		° ′ ″			
		Co Lat.				
		P. Dist.				
		Sum.				
		Diff.				
		½ Sum.		Cosec.	Sec.	
		½ Diff.		Sine	Cosine	
		½ Hor. ∠		Cotang.	Cotang.	
			Arc 1 = Tang.			
Cor.			Arc 2.		Tang. Arc 2	
	App. time					
	Hor. ∠		⊙ true Az. (= Arc 2 − Arc 1)			
	½		⊙ mag. Az.			
	½ hor. ∠ in Arc.		Variation.			

Note.—Arc 2 is of the same affection as the ½ polar dist. and Co. Lat.: when one is acute so is the other, and *v. v.*

Add arcs 1 and 2, when polar dist. is greater than Co. Latitude.

Subtract „ „ less „ „

The angular distance between the Pole-star, which is only $1\frac{1}{2}°$ from the Pole, and any object on the horizon, affords an approximate and simple method of obtaining the true bearing: the formula for the reduction of the oblique to the horizontal angle is

Reduction of Angle.

✱ and obj.	Cosine	
✱ Alt.	Secant	
Red. Angle	Cosine	

The bearing of the Pole-star at all times, or any other celestial object, when on the meridian, affords approximate means of attaining at once, without any calculation, the variation of the compass.

Base-Lines.

By Difference of Latitude.—For base-lines the more rapid methods of attainment are alone suitable to the present object. None of these measures is more accurate and speedy than that obtained by meridional altitudes of the same heavenly body (sun or star, not the moon) at different stations by the same observer with the same instruments. If the stations are on the true meridian, or nearly so, their difference of latitude is their distance; and if they are otherwise situated, their true bearing and their difference of latitude give the distance between them. (*See* p. 305.)

By Micrometer or Sextant, and Short Base.—Should the traveller carry with him an astronomical telescope, it is advisable that it should be fitted with a micrometer for measuring small angles; care is, however, requisite in seeing that the board or object used for the base is accurately measured, and that it is at right angles to the line of sight. In the absence of the micrometer, the sextant will give a very fair approximation; the angle should, however, be measured both on and off the arc. Rochon's micrometer has been used with great effect in the geological survey of Canada.

Table for Rough Triangulation without the usual Instruments and without Calculation. By Francis Galton, F.R.S.

A traveller may ascertain the breadth of a river, or that of a valley, or the distance of any object on either side of his line of march, by taking about 60 additional paces and by making a single reference to the Table on the following page.

TABLE for rough Triangulation without the usual Instruments and without Calculation. By FRANCIS GALTON, F.R.S.

	Angle. °	′	5: 0	5: ½	6: 0	6: ½	7: 0	7: ½	8: 0	8: ½	9: 0	9: ½	10: 0	10: ½	11: 0	11: ½	12: 3	12: ½	13: 0	13: ½	14: 0	14: ½
5 0	28	58	57	60	64	67	70	73	75	78	81	84	87	89	92	95	98	101	105	109	113	118
5 ½	31	56	55	59	62	65	69	72	74	78	81	84	87	90	93	96	100	103	107	112	116	122
6 0	34	56	54	57	61	64	68	71	74	77	80	84	87	90	94	97	101	105	110	115	120	126
6 ½	37	56	53	56	60	63	67	70	74	77	80	84	87	91	95	99	103	108	113	119	125	132
7 0	41	0	52	55	59	63	66	70	73	77	81	85	88	92	96	101	106	111	117	123	130	139
7 ½	44	4	51	55	58	62	66	70	73	77	81	85	89	94	98	103	109	114	121	128	136	146
8 0	47	10	50	54	58	62	66	70	74	78	82	86	91	95	101	106	112	118	126	134	144	156
8 ½	50	20	49	53	57	61	65	70	74	88	83	88	92	98	103	109	116	123	132	141	153	
9 0	53	30	49	53	57	61	66	70	75	79	84	89	94	100	106	113	121	129	139	150		
9 ½	56	4	49	53	57	62	66	71	76	81	86	91	97	103	110	118	126	136	147			
10 0	60	0	48	53	57	62	67	72	77	82	88	94	100	107	115	123	133	145				
10 ½	63	22	48	53	58	63	68	73	78	84	90	97	104	112	120	130	141	154				
11 0	66	44	49	53	58	64	69	74	80	86	93	100	108	117	127	138						
11 ½	70	12	49	54	59	65	70	76	83	89	97	105	113	124	135	147						
12 0	73	46	50	55	60	66	72	79	85	93	101	110	120	131								
12 ½	77	22	50	56	62	68	75	81	89	98	106	117	128	141								
13 0	81	6	52	57	64	70	77	85	93	103	113	125	138	155								
13 ½	84	56	53	59	66	73	81	90	99	109	121	135	150									
14 0	88	52	55	62	69	77	85	95	106	118	132	148										
14 ½	92	56	57	65	73	81	91	102	114	129	145											
15 0	97	10	60	68	77	87	99	110	126	143												
15 ½	101	36	64	73	83	95	108	123	141													
16 0	106	16	60	79	90	105	121	140														
16 ½	111	12	76	88	103	120	141															

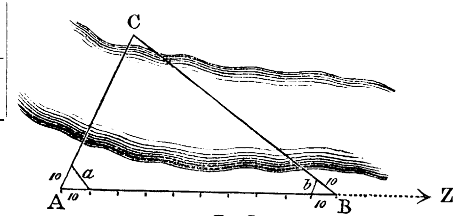


FIG. I.

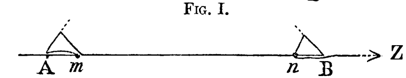


FIG. II.

To find A C and angle A:—Enter with a at the side and b at the top.

To find B C and angle B:—Enter with b at the side and a at the top.

Suppose he is travelling from A to Z (Fig. I.), and wishes to learn the distance from A to C; and, it may be, also the angle A. Let him proceed as follows (referring now to Fig. II.).

1. Leave a mark at A. 2. Walk 10 paces towards Z, and make a mark, calling the place *m*. 3. Walk back to A. 4. Walk 10 paces towards C. 5. Walk to *m*, counting the paces to the nearest half-pace. (This gives the measurement of the line *a* (Fig. I.), which is the chord of the angle A, to radius 10). 6. Walk 80 paces towards Z; make a mark, calling the place *n*. 7. Walk 10 paces towards Z, calling the place B; this completes 100 paces from A. 8. Walk 10 paces towards C. 9. Walk to *n*, counting the paces to the nearest half-pace. (This gives the line *b*, which is the chord of the angle B, to radius 10.)

Now enter the Table with *a* at the side and *b* at the top, and read off the distance A C, and the angle A if also required.

If the Table be entered with *b* at the side and *a* at the top, it gives B C (and B).

Of course the units need not be paces: feet, furlongs, miles, hours' journey, or anything else will do as well; and the units of A B need not be the same as those of *a* and *b*. Also any multiple or divisor of 100 for A B may be used, if the tabular number be similarly multiplied.

Examples.

a (in paces).	*b* (in paces).	A B.	A C.	Angle A.		B C.	Angle B.	
				°	′		°	′
5	6½	100 paces	67 paces	28	58	53 paces	37	56
5	6½	50 miles	33½ miles	28	58	26½ miles	37	56
10½	7	100 paces	68 paces	63	22	92 paces	41	0
10½	7	1000 paces	680 paces	63	22	920 paces	41	0

Particular care must be taken to walk in a straight line from A to B. It will surprise most people, on looking back at their track, to see how curved it has been, and how far B *n* is from pointing truly towards A. It is always well to sight some distant object in a line with Z when walking towards it.

The triangle A B C must be so contrived that none of its angles are less than 30°, or the chords of the angles at A and B will not be found in the Table. These cases cease to give reliable results when the measurements are rudely made, and have therefore been omitted.

Should a traveller have no Tables by him, he can always *protract* his measurements to a scale on a sheet of paper, or even on the ground, and so solve his problem. If real accuracy be

aimed at, it is clear that it may be obtained by careful measurements of the base and chords, combined with a rigorous calculation, as was first suggested by Sir George Everest, formerly Surveyor-General of India. (See 'Journ. R. Geog. Soc.,' 1860, p. 122.)

On a Composition for Keeping Watches or Compasses Watertight. By JAMES BROCK, Chronometer Maker, 21, George Street, Portman Square.

THE method that I should recommend for preventing water from penetrating watch-cases, is the application of a preparation of beeswax and resin to the several parts where it is possible for the water to pass. The preparation I recommend should be composed of equal parts and well mixed. If it is for a very hot climate, the quantity of "resin" should be slightly increased. It may be kept prepared, and when wanted, a portion melted and applied to the several parts with a small brush or feather. If the watch is an ordinary *open-face*, with a SNAP bottom, the parts that should be attended to are—1st, the glass. Apply the preparation round it, and rub it in with the thumb, by which means it will be worked into any cavity. 2nd, open the glass and apply it round the part of the case upon which the glass shuts (be careful that you apply it to all the joints of the case), close the glass and squeeze it down tightly; what is squeezed out may be cleared away with the nail or a piece of wood. 3rd, open the back (where the watch is wound up) and apply the preparation in the same manner as just named. The case will require a little more force to open it, and the back should be attended to frequently. If the watch has a *hunting* (or double) case, or a *bottom that opens with a fly-spring*, the difficulty of keeping out the water is much increased, as there are so many openings into the case for the springs, &c. I should recommend that the springs be removed (which is easily done, as they are all screwed in), and that the holes through which they pass, also the *screw holes*, be stopped up with the preparation; also *remove* the *push-piece* from the pendant (this is done by taking out the screw, which passes through the bow), and stop up the hole from which it has been taken; but care should be used in doing so, as it is essential that it should be stopped *below* the hole through which the screw of the bow passes. The bow may then be returned. The preparation should now be applied to the glass and the shutting parts, in the manner before described. The hunting cover will keep shut by nature of the preparation.

Silvering Sextant Glasses—

(Extract from 'Nautical Surveying,' by Sir E. BELCHER, pp. 9, 10.)

"Before taking leave of this subject it may not be unimportant to describe the operation of silvering the glasses of sextants, as those employed on surveying duties very frequently have to perform the operation.

"The *requisites* are clean tinfoil and mercury (a hare's foot is handy)—lay the tinfoil which should exceed the surface of the glass by a quarter of an inch on each side, on a smooth surface (the back of a book), rub it out smooth with the finger, add a bubble of mercury, about the size of a small shot, which rub gently over the tinfoil until it spreads itself and shows a silvered surface, gently add sufficient mercury to cover the leaf so that its

surface is fluid. Prepare a slip of paper the size of the tinfoil. Take the glass in the left hand, previously well cleaned, and the paper in the right. Brush the surface of the mercury gently to free it from dross. Lay the paper on the mercury, and the glass on it. Pressing gently on the glass, withdraw the paper. Turn the glass on its face, and leave it on an inclined plane to allow the mercury to flow off, which is accelerated by laying a strip of tinfoil as a conductor to its lower edge. The edges may, after twelve hours' rest, be removed. In twenty-four hours give it a coat of varnish made from spirits of wine and red sealing-wax. It may be as well to practise on small bits of common glass, which will soon prove the degree of perfection which the operator has attained."

To fill a tube with mercury as a temporary Barometer-tube, for occasional use.

Take the ladle used for melting lead for bullets, and scour it bright with sand. Prop the tube at a slightly inclined angle on the forks of two sticks, planted in the ground, and rake embers of the camp-fire below it. Turn it till thoroughly warm; almost too hot to touch. Strain the mercury through paper twisted into a cone. Boil it in the ladle. Heat some more mercury in a cup; and let everything cool again. When cool enough to handle, set the tube on end, upon a cloth, to catch overflows of mercury. Fill the tube to overflowing. Put the finger firmly on the top and reverse the tube; plunging the end that is closed with the finger, into the cup of mercury. Then remove the finger gently. If, on inclining the tube, the mercury rises to the top with a sharp tap, it has been filled to the exclusion of all air, and it will do. All that now remains, is to measure with a rule from the top of the mercury in the tube, down to the top of that in the cup. It will be found convenient to have two marks scratched on each tube; the one an inch from its open end, and the other at 30 inches' interval from the one below. Then if the lowermost scratch be brought level with the surface of the mercury, the distance from the uppermost scratch has alone to be measured, and this can easily be done.

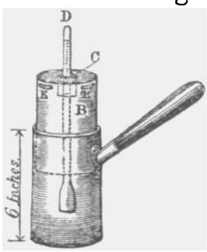
The operation of filling a tube should be practised at home in comfort, with a properly-made barometer for comparison, and plenty of mercury to fall back upon, before trusting oneself to the difficulties of the open field.

Altitudes, by Thermometer in Boiling Water.

The operation of boiling a thermometer is of the simplest nature in theory, but is often extremely troublesome in practice, without a proper vessel to boil it in. This should have a serviceable wooden handle. The lid should be specially made to hold the thermometer, and to give a vent to the steam. The diagram overleaf shows an effective apparatus. The fire on which it is set should be neatly arranged, and be made of dry wood; it must not be too large or smoky, and it must burn steadily. The saucepan should be set firmly, on stones or sods, or across a narrow trench, that there may be no fear of its upsetting, when the fuel subsides. The observation of the thermometer must be made after the water has been boiling freely, but not too tumultuously, for three or four

minutes; and at least four or five readings should be taken, at half-minute intervals. Though pure water ought to be used, yet any water that is not very hard will suffice for a traveller's ordinary need.

The following is the manner in which the observations are taken:—From 4 to 5 inches of water are put into the tin pot; the thermometer is fitted into the aperture in the lid of the sliding tube by means of a collar of cork; the tin tube is then pushed up or down to admit of the bulb of the thermometer being about *two inches* above the bottom of the pot. Free ebullition is continued for three or four minutes, and the height of the mercury is repeatedly ascertained during that time, and the temperature of the air is noticed. Having obtained the boiling points, it remains to determine the value of the indication of barometric pressure from the following Tables, which are fairly approximate, and will serve in the absence of others.



A. A common tin pot, 6 inches high by 3 in diameter.
B. A sliding tube of tin, moving up and down in the pot; the head of the tube is closed, but has a tube let into it, of which the upper opening is C. This holds a cork, through which the thermometer is tightly passed.
D. Thermometer, with only so much of the scale left out as may be necessary.
E. Holes for the escape of steam.

When the thermometer has been boiled at the foot and at the summit of a mountain, nothing more is necessary than to deduct the number in the column of feet opposite the boiling point below from the same of the boiling point above: this gives an approximate height, to be multiplied by the number opposite the *mean* temperature of the air in Table II., for the correct altitude:—

	°		Feet.
Boiling point at summit of the hill	204·2	=	4027
„ its foot	208·7	=	1690
Approximate height			2337
Temperature of the air above ..	75°		
„ „ below ..	83		
Mean	79	= Multiplier ..	1·398
Correct altitude			2·566 ft.

When the boiling point at the upper station alone is observed, we may assume 30·00 inches, or a little less, as the average height of the barometer at the level of the sea. The altitude of the upper station is then at once approximately obtained by inspection of Table I.; correcting for assumed mean temperature of the stratum of air between the upper station and the sea level by Table II.

TABLE I.—To find the Barometric Pressure and Elevation corresponding to any observed Temperature of Boiling Water between 214° and 180°.

Boiling Point of Water.	Corresponding Height of Barometer.	Total Altitude in Feet from 30·00 in. or the Level of the Sea.	Value of each Degree in Feet of Altitude.	Proportional Part for One-tenth of a Degree.	Boiling Point of Water.	Corresponding Height of Barometer.	Total Altitude in Feet from 30·00 in. or the Level of the Sea.	Value of each Degree in Feet of Altitude.	Proportional Part for One-tenth of a Degree.
°		Feet.	Feet.	Feet.	°		Feet.	Feet.	Feet.
214	31·19	−1013	..	..	196	21·71	8407	543	..
213	30·59	507	−504	..	195	21·26	8953	546	..
212	30·00	0	−507	..	194	20·82	9502	548	55
211	29·42	+ 509	+509	51	193	20·39	10053	551	..
210	28·85	1021	511	..	192	19·96	10606	553	..
209	28·29	1534	513	..	191	19·54	11161	556	..
208	27·73	2049	515	..	190	19·13	11719	558	56
207	27·18	2566	517	52	189	18·72	12280	560	..
206	26·64	3085	519	..	188	18·32	12843	563	..
205	26·11	3607	522	..	187	17·93	13408	565	57
204	25·59	4131	524	..	186	17·54	13977	569	..
203	25·08	4657	526	..	185	17·16	14548	572	58
202	24·58	5185	528	53	184	16·79	15124	575	..
201	24·08	5716	531	..	183	16·42	15702	578	..
200	23·59	6250	533	..	182	16·06	16284	581	..
199	23·11	6786	536	..	181	15·70	16868	584	..
198	22·64	7324	538	54	180	15·35	17455	587	59
197	22·17	7864	541	..					

TABLE II.—Table of Multipliers to correct the Approximate Height for the Temperature of the Air.

Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.
°		°				°	
32	1·000	47	1·031	62	1·062	77	1·094
33	1·002	48	1·033	63	1·064	78	1·096
34	1·004	49	1·035	64	1·066	79	1·098
35	1·006	50	1·037	65	1·069	80	1·100
36	1·008	51	1·039	66	1·071	81	1·102
37	1·010	52	1·042	67	1·073	82	1·104
38	1·012	53	1·044	68	1·075	83	1·106
39	1·015	54	1·046	69	1·077	84	1·108
40	1·017	55	1·048	70	1·079	85	1·110
41	1·019	56	1·050	71	1·081	86	1·112
42	1·021	57	1·052	72	1·083	87	1·114
43	1·023	58	1·054	73	1·085	38	1·116
44	1·025	59	1·056	74	1·087	89	1·118
45	1·027	60	1·058	75	1·089	90	1·121
46	1·029	61	1·060	76	1·091	91	1·123

Enter with the mean temperature of the stratum of air traversed, and multiply the approximate height by the number opposite, for the true Altitude.

Meteorological Instructions for the use of inexperienced Observers.

(Extracted chiefly from a Circular issued by the Meteorological Society.)

THE chief object of an inexperienced meteorological observer should be to obtain data whence an accurate table may be compiled, of the following character:—

Place				
Lat.		Long.		Elev^{n}
	Mean temp.	Monthly range.	Rain, &c.	Periodical winds.
Jan.				
Feb.				
Mar.				
April				
May				
June				
July				
Aug.				
Sept.				
Oct.				
Nov.				
Dec.				
Year				
No. of years' observation				
Hours and mode of observation ..				

The original observations should be carefully preserved, in order to give evidence of the sufficiency of the data whence the printed results have been obtained, and to afford opportunity of investigating such anomalies, as may at any future time call for inquiry.

The following instructions show the minimum of effort with which trustworthy results can be obtained. They are especially intended for residents. Travellers on the march must act up to their spirit, as nearly as they can.

OBSERVATIONS ON HEAT.

1. *To Expose Thermometers.*—The instrments must be placed in a carefully selected position, or all their results will be vitiated. Choose an airy place, where there is continuous, dense, and ample shade. There set up a box of not less than 2 feet in height, width, and depth. It must be constructed precisely on the prin-

ciple of an ordinary meat-safe; that is to say, it must be roofed (and better still, double roofed) from the rain, and have perforated sides, whether of gauze, trellis-work, or Venetian blinds, through which the air may pass with perfect freedom. It must be fixed on a stand or be suspended 4 feet above the ground. The thermometers should be hung on supports placed in the middle of the box, except where otherwise mentioned in the 1st method, § 3.

2. *Monthly Mean Temperatures.*—The average of the daily means, taken by one of the methods described in the next paragraph during an entire month, gives the monthly mean. If occasionally a day or a month be dropped, a gap must be left in the record, and no attempt be made to fill it.

3. *Daily Mean Temperatures.*

1st Method: This is the more accurate, but requires observations to be made *twice* in each day.

Procure a jar or box, of not less than 8 inches in length, width, and depth; fill it with dry sand, and set it in a properly exposed box (§ 1). Place a thermometer upright in the middle of the sand, with its bulb buried from 3 to 4 inches below its surface. Note its readings twice a day, at intervals of twelve hours, say at 9 A.M. and 9 P.M.; the mean of these readings may be accepted as the daily mean.

2nd Method: By observations made *once* in each day.

Hang a maximum and a minimum thermometer on supports, as described in § 1, and note their readings once daily, either in the morning or in the afternoon, and readjust the indexes. The mean of the maximum and minimum usually differs from the mean temperature of the day by less than half a degree; but occasionally (as at Barnaul in Central Asia) the difference exceeds $1\frac{1}{2}°$. The liability to a constant error of this amount is too serious to be passed over without investigation, especially as the approximate correction due to each month can be readily ascertained by making occasional use of the 1st method as a standard of comparison. When the year's work is completed, it will be easy to estimate the corrections due to the several months, and to apply them to the monthly means obtained by this 2nd method.

4. *Monthly Range* is the difference between the lowest and highest readings during the month.

5. *Yearly Means*, whether of *temperature* or of *range*, are the averages of the monthly means.

"The enclosure of a maximum and minimum self-registering thermometer in a large cask of dry sand, which might be opened and read off twice a year, would also probably afford a very accurate mean result."—*Sir John Herschell.*

Rain, Snow, and Dew.

6. These must be measured by a Gauge, which should be placed on the ground or on a low stand in an exposed situation. The relation of the units of length and weight is such that the tenth of an inch of rain falling into a vessel whose mouth is a circular area of about two inches and nine-tenths in diameter (1·4467 inch radius) will weigh an ounce (Troy). Every medicine-chest contains a fluid ounce (Troy) measure; and, failing this, it will suffice to mark the space occupied in a small vessel by 480 drops of water, whose weight is one fluid ounce. A properly made rain-gauge and graduated measure is, however, preferable to any makeshift.

Wind.

7. Practised observers rarely use a weathercock, but watch the way the clouds (when any) are drifting. These are far steadier in their course than anything driven by the surface-currents of wind. For the requirement of the tabular statement now desired, it will be sufficient to note the prevalence of periodical weather.

Extracts from a Letter from John Kirk, M.D., F.L.S., &c.

It seems to me that I cannot better carry out the wish of your Committee than by briefly reviewing the various instruments which proved of use during the expedition into East tropical Africa, on which I had the honour to serve under Dr. Livingstone for upwards of five years as chief officer, surgeon, and naturalist. It is not necessary to make reference to work done near the steam-vessel; there every appliance needful for a complete survey might be found. My remarks shall, therefore, be restricted to the land-journeys, where, to secure success, it was necessary to limit the number of our party and reduce to its utmost the baggage, consistent with obtaining scientific information regarding the countries traversed. On such an expedition every pound weight saved is so much more cloth, &c., carried, and represents so many more miles traversed. To this, however, there is a limit, as the instruments must be complete, else the journey were almost time and labour thrown away.

Perhaps no exploring party has travelled in lighter marching order than we did, and yet taken with it the means of scientific research.

Our equipment might be classed as astronomical, meteorological, botanical, and zoological—the heavy loads being barter goods. No tent was carried, and our own personal baggage, besides firearms and ammunition, consisted of a bag of bedding and spare clothing.

When Dr. Livingstone and I crossed the mountains and reached Lake Shirwa, our outfit was as follows: one 6-inch sextant, one mercurial horizon, one pocket chronometer, two prismatic compasses, one pocket compass, one field-glass, one aneroid barometer, two common thermometers, two boiling-point thermometers (the brass apparatus commonly supplied is quite superfluous), botanical paper, arsenical soap, one wide-mouthed bottle containing spirits

of wine, pocket-lens, knives, note-books, water-colours, mathematical tables, nautical almanack, and wax candles.

The sextant and horizon were under the care of one man. They are on no account to be contained in the same box, partly from the danger of escape of mercury, but more especially to avoid the severe shock which so heavy a weight receives when placed on the ground, or should it happen to strike against a rock or tree; and these are contingencies to be expected. When carried, the limb should be very lightly clamped on the arc. We found no better plan when on the march than having the sextant and horizon fastened to opposite ends of a bamboo or stick, and carried over the shoulder of one of the porters. All the other instruments not carried by ourselves were packed among the other baggage. We read off the sextant by the help of the wax candles, which, from the stillness of the nights, we were able to use in the open air. On a short journey such an outfit is all that can be desired.

Rate of Travel.—I may state that the usual distance accomplished each travelling day was 10 miles geographical in direct line, without regarding small detours in order to avoid marshes, hills, or nullahs, and the common rate per hour measured in the same way 2¼ miles. Of course this is only true of a long journey; individual days' marches will vary much, reaching 20 miles in a country such as the Batoka plains, and falling to 5 miles after hard continued labour throughout the day, as we found among the hills near the Shiré before they had been mapped in, or by the side of the Zambezi, in the gorge of Kebrabasa, from which all the party, excepting Dr. Livingstone and myself, were forced to turn.

Thermometric Observations.—Maximum and minimum thermometers are of great use; also observations on the temperature of the earth at various depths and of large bodies of running water. Of more importance than delicacy of instruments is the skill shown in the selection of a spot for meteorological observations, free from radiation at night and solar heat by day, whether directly or as coming from local currents off heated sand or blackened rocks.

Collecting Plants and Animals.—I shall only remark that a very valuable series, illustrating both Flora and Fauna, may be packed in very small compass, if judiciously selected and accompanied by notes; but for this a knowledge of each department is needed. Duplicates are to be carefully rejected, and the members of numerous genera sacrificed for others, showing variety of form. Of course, where practicable, a collection cannot be too large or the duplicates too numerous; but the explorer will seldom be encumbered with many specimens.

On the outfit needed to follow Natural History I need not dilate. Each branch would require separate instructions; but for the geographical traveller desirous to do something, all I can say is that his knowledge and common sense must guide him in selecting from the riches around, what he shall bring home. Things of economic uses are always more important than mere curiosities; for, without a scientific knowledge, he will not know the kind of rarity which will be valued at home. He will find common brown paper the best for drying plants, arsenical soap the best preservative for skins, and spirit the only good fluid for wet specimens.

In sending home cases, unless the contents are thoroughly dried, it will not be advisable to close them up in soldered cases, which too often confine the damp and cause mouldiness. A tin-lined box with any flaw in it is worst of all; it will not only admit but retain any water that may fall on it.

Photography is little suited for distant and wild countries, yet where it can be employed is of the greatest service (*See* p. 293). When abandoned, the camera lucida will take its place in delineating natural objects. I shall not now try to induce the traveller to carry with him an apparatus to Central Africa or any such place, but only mention what I found of use on the lower Zambezi. My instru-

ment was an ordinary landscape camera, made by Negretti and Zambra, which, after travelling or lying about for five years in the tropics, came home without a joint loose or slip of wood started. The process adopted was the waxed paper, which, for simplicity of apparatus, and chemicals, and facility in the transport of negatives, has not been surpassed.

One great advantage which I found was the absence of the smell of collodion, which in a hot country seems to be very injurious, and still more of the acetic acid, which I replaced by the citric. The negatives, if washed in the bromide of potassium, need not be fixed for many weeks after, and when finished, if melted together into a cake with bees-wax, may be taken anywhere without danger, and again separated and ironed out at home.

The dry collodion process, which I believe will now supersede almost all others, had not made much progress when we went out; but in order to test it I took with me plates, prepared and sensitised in England in January, 1858, which, when tried at various times, continued to yield pictures up to August, 1863, having been kept sensitive all the interval at Teté on the Zambezi.

Medicine.—I feel some hesitation in mentioning the requisites for the explorer's medicine-chest (in tropical Africa). If he be one of the profession, he will fit it out according to his own views; but the following may be of use to the non-medical traveller, and I may say, in the first place, that it need not occupy much space, otherwise he may be tempted to use it too often :—

Quinine is the most essential of its contents, and the least apt to harm. In the cure of fever it cannot be overestimated; as a preventive it has utterly failed on the East coast, and thus belied the good name given it by many in other parts. The traveller should be well supplied with quinine of the very best quality; all unbleached kinds are so much impurity; they are no cheaper in reality, and nauseous from the larger dose needed. It may be well to bear in mind that although in mild cases it is as well to precede the quinine by opening medicine, yet that in severe cases it may be given at any stage of the attack and in large doses, from 5 to 20 grains.

Calomel.—If the traveller knows but little of medicine, let him dread this when taken in oft-repeated small doses; it will be in combination with other purgative medicines, such as *resin of jalap* and *rhubarb*, that it is needed; and the best compound he can take in fever will be the following :—quinine, rhubarb, calomel, jalap-resin, three grains of the former and four of the latter, mixed together in powder and made into pills, as needed.

The other remedies next in importance are carbonate of soda, opium, Dover's powder, nitrate of silver, and blistering-fluid. If he is troubled with weak eyes, a 2-grain to the ounce solution of nitrate of silver will perhaps relieve it; but many of the eye-complaints among Europeans in Africa are of a deep-seated nature, indicating a system much reduced and in need of change.

In tropical Africa sunstroke is little dreaded, and the protection to the head necessary in other countries is not requisite; but the clothing should be of flannel or serge. Besides the risk from crocodiles, bathing in the African rivers early is dangerous, for then the water is warm and the air cold.

Before commencing the morning march, a cup of coffee or tea should always be taken, and wet shoes or stockings removed when at rest: nothing is more certain to bring on fever than wet feet.

PHOTOGRAPHY.

"The following note on Portable Photography was written in 1862. The improvements I urged in the dry-plate manufacture have not been carried out, probably for want of sufficient demand; but still, even in the present state of things, one can get on tolerably well.

"I still use my apparatus as before, and, except the addition of an extra lens, to shorten the exposure in difficult cases, I have seen no reason to make any alteration.

"Very sincerely yours,

"W. Pole."

Photography for Travellers and Tourists. By Professor Pole, F.R.S.

[Reprinted, by permission, from 'Macmillan's Magazine.']

Doubtless, the idea must often have occurred to almost every traveller, what an advantage it would be if he could himself take photographs, where he likes, of what he likes, when he likes, and how he likes. But such an idea must soon have been dismissed, from the supposed incompatibility of this with ordinary travelling arrangements. The usual notion of photographic operations comprehends a fearful array of dark rooms, huge instruments, chemical paraphernalia, water, and mess, which no sane person, out of the professional photographic guild, would think of burdening himself with on an ordinary journey, and which only a practised adept could use if he had them; and so the idea of a traveller's taking views for himself on his tour is generally dismissed at once as an impracticable chimera.

Now, it is the object of this article to show that such a view of the matter is a delusion, and that any traveller or tourist, gentleman, or lady, may, by about a quarter of an hour's learning, and with an amount of apparatus that would go into the gentleman's coat pocket, or the lady's reticule, put himself or herself into the desirable position we have named.

It is not our intention to write a treatise on photography; but we must state generally what the operations are, in order to make our explanations intelligible.

The process, then, of taking a photographic picture consists essentially of three main divisions, namely—1. Preparing the plate; 2. Taking the picture; and 3. Developing the image; and the most common and best known arrangement of these is as follows:—A glass plate of the proper size is coated with collodion, and made sensitive to light by dipping in a bath of a certain solution. It is then, *while it remains moist*, placed in the camera obscura, and exposed to the image formed by the lens; after which, *but still before the plate has had time to dry*, it is taken out, and treated with certain chemicals which have the property of developing the image so obtained. The plate is then what is called a "negative;" from which, after it has been secured by varnish, any number of impressions or "prints" may be taken at any time.

Now, it will be seen by the words we have printed in italics, that, according to this method of operation, the whole of the three parts of the process must be performed within a very short space of time; and, since the first and third require to be done in a place to which daylight cannot enter, a dark room,

supplied with a somewhat extensive assortment of chemical apparatus, must be provided *close to the place* where the picture is taken. This method, from the necessity of the plate remaining moist, is called the *wet* process. It is always employed for portraits, and has the advantage not only of great beauty of finish, but of extreme sensitiveness, requiring only a few seconds' exposure in the camera.

The wet process was the first, and, we believe, for some time the only collodion process in use. But, in a happy moment, it occurred to somebody to inquire whether it was really indispensable that the plates should be kept *moist* during the whole operation; and it was found that, by certain modifications of the process of preparing them, they might be allowed to *dry*, and that some time might elapse between the preparation and the exposure, as well as between this and the development. The immense advantage this promised to landscape photography led to extensive investigation; and several processes have now been perfected which will secure this result. Plates may be prepared at any convenient time and place, and may be carried about for months, ready for use at a moment's notice; and, after the picture is taken, they may also be kept some time before development. The only price we pay for this advantage is the necessity for a little longer exposure in the camera; which, for landscapes, is of no moment at all.

The bearing of this discovery on our more immediate subject will be at once apparent, as it gets rid of the necessity of providing, on the journey, for the preparation and development, with all their cumbersome and troublesome apparatus, and limits what is necessary to the simple exposure, or taking of the picture. And another advantage of still more importance follows from this—namely, that the plates may be prepared and developed, not only in another place, but by another person. The knowledge, care, and skill required for photography, as well as the stains and all other disagreeables attending it, refer almost exclusively to the preparation and development; the exposure to take the view is an operation of the simplest kind, which anybody may learn in a few minutes, and which is attended with no trouble or inconvenience whatever.

Limiting, therefore, the traveller's operation to the taking of the picture, let us consider what this involves. The first question which affects materially the portability of the necessary apparatus, is the *size* of picture to be taken. We are accustomed to see very large and beautiful photographs of scenery and architecture; but these would be impracticable for the traveller, as the dimensions of the plate increase so materially every portion of the apparatus. Differences of opinion and of taste may exist as to the degree of inconvenience it is worth while putting up with; but the writer of this paper, after considerable experience, has come to the conclusion that the smallest size in ordinary use—namely, the *stereoscopic* plate—is by far the most eligible one for travelling. The object is not to make large and valuable artistic pictures —that we must always leave to the professional man—but it is simply to preserve faithful representations; and this may be done as well on the small as on the large scale, and with infinitely less trouble. For, though the size is small, the delicacy of detail procurable with well-prepared plates, even in a large extent of view, is something marvellous, as may be easily seen in some of the magnificent stereoscopic views that are to be had in the shops; besides which, the stereoscopic effect gives an air of reality to the view which greatly enhances the value of the representation.

The camera for taking stereoscopic views has now been reduced, by ingenious contrivances, to a very portable size. The one used by the writer is nine inches long, five and a half inches wide, and three inches high—about the dimensions of a good-sized octavo book. It weighs a little over two pounds, and hangs by a strap round the neck in walking with no inconvenience. The stand folds up into a straight stick, which is carried easily in the hand. A

stock of eight plates, in slides ready for use (sufficient generally for a day's operations), go into two folding pocket-cases. The tourist can thus walk about without the slightest sense of incumbrance, and is prepared, at any moment, to take a perfect stereoscopic view of anything he sees—an operation which will occupy him from five to fifteen minutes, according to the light, and the time he may take to choose his position.

Considered as adding to the baggage of the traveller, these things are hardly worth mentioning—as, with the exception of the stand (which travels well in company with an umbrella), they will all lie snugly in a spare corner of a portmanteau. Of course, however, a stock of plates must be added. A dozen of these, with appropriate packing, will occupy about 8 inches long, 4 inches wide, and 1½ inch high; and from this the space occupied by any number it is proposed to take on the journey may be easily estimated. Suppose there are five dozen—a pretty fair allowance—these, with camera and all complete, will go into a very portable hand-box, or into one of the small black leather bags now so common.

If the operator chooses to go to a little extra trouble, it is highly satisfactory to be able to *develop* the plates on the journey—which may conveniently be done in the evenings, at a hotel or lodging; and the apparatus for which adds very slightly to the bulk of the preparations. A small case of bottles, 5 inches square and 2½ inches thick, together with one or two small loose articles, are all the author takes with him. The development of a plate takes five or ten minutes, and is a process easily learnt; and the satisfaction of being able to see the same evening what one has been doing in the day, is quite inducement enough to do it. But still, we repeat, this is not *necessary*, as the development may be left to another person and to another time.

We think we have shown how every traveller or tourist may be his own photographer, with much less trouble and difficulty than is generally supposed; and we must add that this is no untried plan. The writer of this article has been much in the habit of travelling; and, for years past, when he has gone on a journey, the little camera has been put into the portmanteau, as unassumingly and as regularly as the dressing-case. It has travelled in all sorts of countries, and has cast its eye on scenes which camera never looked at before; it has been a never-failing source of interesting occupation and amusement, and has recorded its travels in hundreds of interesting views, some of much excellence, and very few otherwise than successful.

But it may be asked, Since the advantage and usefulness of this plan are so undeniable, how is it that we do not see it in more frequent use? Simply for the reason that the dealers in photographic apparatus have never yet had the enterprise to establish a manufacture and sale of dry prepared plates, in such a way as to insure their popularity.

The manufacture and sale of photographic apparatus and chemicals is now becoming a very large branch of commerce; but many of the large numbers of tradesmen who prosecute it appear to have a much more earnest view towards the profits of the business than to the advancement of the art—for, since the death of poor Mr. Archer (to whom we owe almost entirely the present state of photography, and who lost a fortune in its improvement), nearly every advance made has been by private individuals. We must not be misunderstood. There are many people who profess to sell dry plates, and these may often be found to possess many of the requisites they should have; but few can be depended on, and *none* combine all the qualities which are necessary to give the system the full benefit of its inestimable value. Some will not keep long enough before exposure; some will not keep at all after exposure; some fail in sensitiveness; some spoil soon after they are opened; to say nothing of the constant liability to stains, irregularities, blisters, and all sorts of troublesome and annoying defects, which not only spoil the operator's work, but—what is of more importance—destroy all reliance on his operations, and so dis-

courage him from undertaking them. We are not sure whether some dealers may not be obtuse enough even to encourage defects, from the short-sighted notion of increasing the sale; but this we can say—that we know no maker who will guarantee the sincerity of his wish to make good plates, by consenting to allow for them if they turn out bad ones. If this state of things arose from imperfection in the art, we should not grumble, but could only urge improvement; but this is not so. It is well known that dry plates *can* be made, satisfying all the conditions we have named, and which, with care and system in the manufacture, might be rendered thoroughly trustworthy. It is only the indolence or obstinacy of the trade that prevents their becoming regular articles of commerce.

We do not wish, however, to discourage the traveller who may wish to adopt this admirable aid to his wanderings; for the object to be gained is so important that it is worth striving a little for. In the present state of the matter, he must either learn to prepare his own plates—which, after all, is no great exertion—or, if he buys them, he must at least learn to *develop* them, and must, at the same time, lay in with them a certain stock of patience and temper to meet disappointment; and we can assure him that, even at this price, he will find himself amply repaid. But we again urge that the case ought not to stand thus. The application of the dry processes to portable photography offers a boon almost inestimable to, but yet quite unappreciated by, the traveller and the tourist; and it only needs the zealous and earnest co-operation of the dealer, by so conducting the manufacture as to render it perfect and trustworthy, to raise this application into a branch of commerce of an extent, importance, and profit, little inferior to any in the trade. (*See* p. 291.)

Hints on the Projection of Routes. By Staff-Commander C. George, R.N., Curator of Maps R.G.S.

For out-door or field work the easiest method is by the plane projection, the data thus obtained being transferred to a Mercator's projection at the first halt or stopping station.

In the plane projection one equal length is assigned to all the degrees of latitude and longitude. It was first adopted on the erroneous supposition that the earth's surface is a plane. It is still the best for the traveller to use in his early attempts to project his journey, while the objects are still in sight. This projection is available as far as 20° on either side of the Equator;—beyond the parallel of 20°, and as far as 60°, Mercator's projection is preferable;—between 60° and the Pole, the distortion of both the plane and Mercator's projections is so apparent, that a polar or circular projection must be adopted.

Sheets of paper, ruled into squares by strong lines and subdivided by finer ones, afford great assistance in map work.

For *out-door* work, the scale of 1 inch to 1 mile is amply large enough to register every particular of one day's journey on a sheet 12 inches square:—the *indoor* or table-plan may be reduced to 10 miles to the inch, and plans for transmission home may be again

reduced to 1 inch to 1 degree, when the larger plans cannot be sent.

The chief point aimed at by the following directions is to draw more attention than has hitherto been given to the "*true bearing*" of objects, for the following reasons:—

1st. Any object whose true bearing is *east* or west, must be in the same LATITUDE as the place of the observer.

2nd. Any object whose true bearing is north or south, must be in the same LONGITUDE as the place of the observer.

While travelling in a northerly or southerly direction from a station whose latitude is known, and carefully noting the distance and direction travelled, it is only necessary to watch when objects come to the "true" east or west; and their latitude is obtained.

When travelling in an easterly or westerly direction from a fixed station, noting distance and direction, it is only necessary to watch when objects come to the true north or south, and their difference of longitude can be obtained, by using Table B, p. 305, from the station left.

Thus, suppose a traveller passes from A, whose latitude is known, towards some distant hill, B; his route making an angle of 25° with the meridian. He sets his sextant to 65° (65° + 25° = 90°), or to 115° (180° - 65°); then as the objects 1, 2, 3, and 4, successively come into contact with B or A, as the case may be, he ascertains with precision the moment when they are truly E. or W. of him; and so, knowing the distance he has travelled from A, he can readily calculate or protract their latitude.

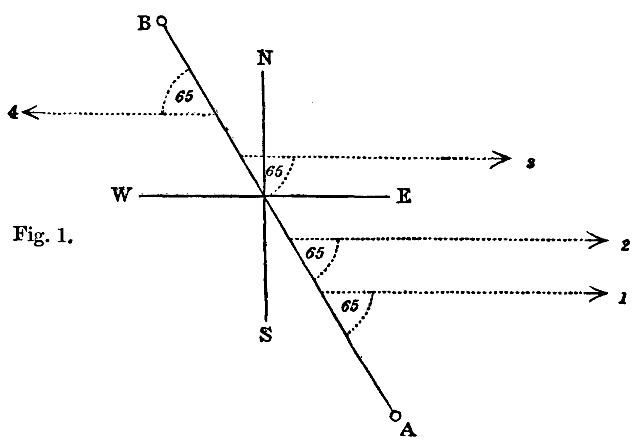
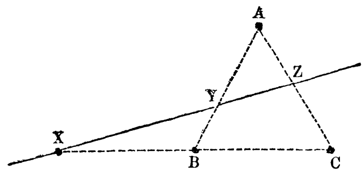


Fig. 1.

When the traveller, as will frequently be the case, has to deviate from the line of route, his position can be determined by compass or true bearing of any object, and an angle to a second object.

Or he may have recourse to transit observations; that is to say, whenever two fixed objects come in line, an angle to a third object will determine the position with great accuracy.



Observe, that in travelling along X Y Z, the hills A B C can be mapped; for at X, or thereabouts, the bearing of B from C can be determined; at Y that of A from B; and at Z that of A from C; and so on for any number of hills. And it is very important to recollect that it is not necessary to catch these lines of sight precisely; for by taking bearings twice, and the intermediate course approximately, there are sufficient data for protracting out upon paper the required bearing. Thus, as soon as the peak of a distant hill is about to be occulted by the shoulder of a nearer one, a bearing should be taken; and again another one as soon as it has reappeared on the other side, and the intermediate course noted.

The advantage of this method of filling up a field-sketch will become more apparent as experience is gained. A third and accurate method of fixing the position is in general use among marine surveyors, but has hitherto been but little resorted to by land travellers, viz., by the angles subtended between three known objects. The instrument called the station-pointer is generally used for this purpose, but the position may also be found with a pair of compasses and a protractor, or, more simply, as follows, by means of a protractor and a sheet of tracing-paper. Draw a line through the centre of the paper; place the protractor on it near to the bottom of the sheet; lay off the right-hand angle to the right, and the left-hand angle to the left of the centre line; rule pencil-lines, radiating from the point over which the centre of the protractor had been placed, to the points that had been laid off; then place the paper on the plan or map, and move it about until the three lines coincide with the objects taken; prick through the points that lay beneath the centre of the protractor, and the observer's position is transferred to the plan. When possible, the centre object should be the nearest.

To Construct a Map on Mercator's Projection.

On a sheet of cartridge paper, 13 inches by 20, it is proposed to construct

(A.)—Table to construct Maps on Mercator's Projection.

	0	1°	2°	3°	4°	5°	6°	7°	8°	9°
°		° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
0		1 00	1 00·1	1 00·1	1 00·1	1 00·2	1 00·3	1 00·4	1 00·5	1 00·6
10	1 00·9	1 01	1 01·2	1 01·5	1 00·7	1 02	1 02·2	1 02·6	1 02·9	1 03·3
20	1 03·6	1 04·1	1 04·5	1 04·9	1 05·5	1 05·9	1 06·5	1 07	1 07·7	1 08·2
30	1 09	1 09·6	1 10·4	1 11·1	1 12	1 12·8	1 13·7	1 14·6	1 15·7	1 16·7
40	1 17·6	1 19	1 20·1	1 21·4	1 22·7	1 24·2	1 25·6	1 27·1	1 28·8	1 30·6
50	1 32·4	1 34·3	1 36·4	1 38·6	1 40·8	1 43·4	1 45·9	1 49	1 51·4	1 54·8
60	1 58·3	2 01·8	2 05·8	2 09·9	2 14·5	2 19·14	2 24·7	2 30·5	2 36·8	2 43·8
70	2 51·3	2 59·8	3 09·1	3 19·6	3 31·3	3 44·6	3 59·8	4 17·1	4 37·4	5 01·1
80	5 29·5	6 03	6 46·4	7 40·3	8 51·1	10 27·7	12 47·9	16 29·6	23 14·3	39 42·2

Use of the Table.

Find in the Table the required parallel: the tens at the side, and the units at the top. At their intersection, will be found, in degrees and minutes, the distance of the required parallel from the next less degree; to be measured from the scale of longitude on the map in progress.

Given the parallel of 30°—required that of 31°.

30 at the side, and 1 at the top, intersects at 1° 09′·6, the required distance of the two parallels.

Given the parallel of 31°—required that of 33°.

32° = 1° 10′·4
33° = 1° 11′·1

2° 21′·5 the distance between the 31° and 33° parallel.

to construct a map on Mercator's projection, on a scale of 10 miles to an inch equatorial—*i.e.* 6 inches to a degree of longitude.

Limits of the Map $\left\{\begin{array}{l}\text{Lat. } 31^\circ \text{ to } 33^\circ \text{ N.}\\ \text{Long. } 34^\circ \text{ to } 36^\circ \text{ E.}\end{array}\right.$

Draw a base line, find its centre, and erect a perpendicular to the top of the paper; the extremes of longitude 34° and 36° added together and divided by 2, give 35° the central meridian, and which is represented by the perpendicular; on each side of it lay off 6 inches, and erect perpendiculars for the meridians 34 and 36; divide the base line into 10-mile divisions, and the part from 35° 50′ to 36° 00′ into miles for the latitude scale.

From Table A, take the following quantities:—

Lat. 31° to 32°	=	1° 10′·4	=	the distance between parallels	31° and 32°
„ 32° to 33°	=	1° 11′·1		„ „ „	32° „ 33°
		2° 21′·5		„ , „	31° to 33°

Having thus obtained the distances between the required parallels, divide the map into squares of 10 miles each way, and the map is ready for the projection of the route.

The following is to explain what has been said on the subject of "true bearing" and the traveller's route, also to exercise him in the use of his protracting instruments, in laying down his route and observations, &c., and to draw his attention to objects noticeable around him; the field of exploration is supposed to be Palestine, and by comparing his sketch, with a map of the same, he will at once see his proficiency. The following symbols have been used:—

∠'s signifies angles.
◬ a station in the triangulation.
$\ominus$ „ fixed by latitude.
Φ „ „ longitude.
$\oplus$ „ „ lat. and long.
$\odot$ „ „ true bearing.
R. t. „ „ right tangent.
L. t. „ „ left „

The Field Book.

At No. 1 ◬.

From a village on the bank of a river in lat. 31° 00′ E. and long. 35° 17′ E., proceeded to an elevated position No. 2, and camped; the route was N. 6 E. by compass, the variation being 6° westerly: distance 5 miles.

At No. 2 ◬.

Early in the morning, when the sun was its own diameter above the horizon, measured with a sextant the angle between the northern limb of the

sun and a distant high peak to the N.E.; the time being taken at the same moment, showed the watch to be about 5 min. slow.

With the azimuth compass several observations were made of N.E. peak; the needle being deflected after every observation, gave the mean reading of N. 36° 40′ E.; this object, of which the "true bearing" had been obtained, was, as is usually the case, then made "zero," and a round of sextant angles taken to conspicuous objects.

∠'s and Observations.

		°	′	″
Latitude by ☉'s N. and S. of zenith	.. .. ..	31	5	30 N.
True bearing of N.E. peak	.. ..	N. 30	40 E.	
Compass „	.. ..	N. 36	40 E.	

For height of △. Temp. of boiling-water 208°·6. Aneroid 28·16
Temp. of air (in shade) .. .. .. 71°·00

	°	′
N.E. peak, and r. t. of lake to the eastward	53	40
„ near point on opposite side of lake ..	22	00
Two conical peaks in line and N.E. peak	30	40
Village on the sea-coast	85	05
Direction of this range	102	30
L. t. of near range	110	30
R. t. „	30	40

Remarks at this △. In the direction of N. 6 E. by compass were noticed two distant conical peaks in line, which at once determined the direction of route; it was also observed that the near range in the direction of the line of route was higher than No. 2 △, and on the way three streams would have to be crossed.

Proceeded onwards—

	°	′
At No. 1 stream, ∠ between conical peak and N.E. peak	31	10
„ No. 2 „ „ „	32	00
„ No. 3 „ „ „	35	15

All these streams run eastward, towards the lake.

Arrived at the foot of No. 3 △, encamped for the night; had travelled, by estimation, N. 6 E. 12 miles. Observed for lat.

At No. 3 △, top of Range.

The morning amplitude was not obtained, the sun being obscured by clouds; waited half an hour until the sun had risen 15°, and then obtained a set of azimuth observations.

		°	′
	Latitude by ☉'s N. and S. of zenith	31	14 N.
	True bearing of N.E. peak	N. 37	10 E.
	Compass bearing „	N. 43	10 E.
	N.E. peak, and the low range of yesterday 125° 0′ to	174	30
	„ and r. t. of lake	88	00
β	„ point on opposite shore of lake	53	30
	„ tongue point in lake stretching northward	23	30
	No. 1 village on sea-coast and N.E. peak	101	50
	No. 2 „ „	63	00
	Direction of this range „	153	30

Remarks.—This bearing (β) is east true, therefore the point on opposite side of lake is in the same lat. as △ No. 3, and having been crossed by a true bearing from No. 2 △, it becomes a fixed point.

From this △ was obtained a good view of the lake (see Sketch-book) for that portion to the southward of east; from thence it appeared to run northerly, somewhat parallel to the line of route, with a breadth of 8 or 10 miles, and numerous feeders running into it from both sides, and nearly at right angles to the coast-line of the lake. In the direction of the intended route-line there appeared a great number of streams, all of which will be fixed by angle between the conical peaks in line and N.E. peak; the line of route was kept by measuring angle between the third △ and the conical peaks, subtending ∠ of 180°.

Travelled on for the next two days, crossed several streams and fixed them; they apparently rose on the high land to the westward, and all running towards the lake; made about 25 miles northing, and then arrived at the nearest of the two conical peaks that had been kept in line.

At No. 4 △ South Conical Peak.

	° ′
Lat. by ✱'s N. and S. of zenith	31 41 N.
True bearing of N.E. peak	N. 76 0 E.
Compass "	N. 82 0 E.

	°
For height of △. B. W. 208°·30. Aneroid	28·00
Temp. of air	67·00

	° ′
North conical peak to N.E. peak	76·00
No. 1 village on sea-coast and N.E. peak	180·20
No. 2 " "	124·10
Large town to northward on the western slope of the North conical peak and N.E. peak	78·10
Mouth of large river falling into northern end of lake, and N.E. peak	4·10

Remarks.—This was the highest △ yet visited. From it were seen several rivers running from the high range westward of the line of route towards the sea, therefore it is the dividing range between the lake and the sea.

Travelled on 6 miles to the northernmost of the two conical peaks, taking care to keep in line between the conical peaks, and when there make it a recruiting △, and visited the town on the western slope.

∠'s at No. 5 △ North Conical Peak.

	° ′
Lat. by ✱'s N. and S. of zenith	31 46 N.
True bearing of N.E. peak	N. 90 00 E.
Compass "	S. 84 00 E.

	°
Eor height of △. B. W. 207°·00. Aneroid	27·18
Temp. of air	69·00

	° ′
A sharp peak and N.E. peak	33·25
N.E. peak and No. 3	90·00
Tangents of distant range running this way, and N.E. pk.	95·30 101·35
A point on the sea-coast and N.E. peak	102·00
N.W. peak, and N.E. peak	87·15
" a sharp peak	53·50

Remarks.—Finding by the true bearing that N.E. peak was in the same latitude as this △ No. 5, the line of route was altered to go to N.E. peak.

At 10 miles distance travelled, observed that the west shores of the lake were south true ⏀.

At 16 miles travelled, arrived at the mouth of a river seen from No. 4 △ running into the lake from the north.

∠'s at Mouth of River.

	° ′
Eastern shores of the lake	South (true) ⏀
No. 3 △, and last △ No. 5	63·30
Last △ No. 5, and run of large river, running north	92·40
Distant range to the N.W., runs to this △, ∠ to No. 5 △	64·30

Travelled on to the N.E. peak, or No. 6 △.

∠'s at No. 6 △ N.E. Peak.

Distance travelled from No. 5 △, 24 miles east (true).

	° ′
Lat. by ✱'s N. and S. of zenith	31 46½ ⊖
True bearing of sharp peak to northward	N. 3 30 E. ⊙
Compass „ „	N. 9 30 E.

	°
For height of △. B. W. 211°·00. Aneroid	29·42
Temp. of air	73·00

	° ′
No. 5 △ and sharp peak	93·30
No. 3 △ and No. 5	52·50
N.W. peak and sharp peak	24·50
„ No. 5 △	68·40

Proceeded northward to sharp peak No. 7 △; travelled 17 miles, crossed several streams, apparently the feeders to the large river running northward, fixed them by angles subtended between No. 5 △ and No. 6 △.

∠'s at No. 7 △ Sharp Peak.

	° ′
Lat. by ✱'s N. and S. of zenith	32 03½ ⊖
True bearing of a peak N.W.	N. 30 30 W. ⊙
Compass „	N. 24 30 W.

	°
For height of △. B. W. 202°·00. Aneroid ..	24·58
Temp. of air	74·00

	° ′
N.W. peak, and flat-top mountain	49·20
„ No. 6 △	145·35
No. 5 △ and N.W. peak	92·30

Travelled on towards N.W. peak; at 15 miles came to the large river running to the south.

∠'s at Large River.

	° ′
N.W. peak, and flat-top mountain	92 20
Flat top mountain, and No. 7 △	90 40

At the distance of 26 miles, observed that No. 7 to flat-top mountain measured 59° 30′ ⊖.

At 30 miles' distance came to an elevated △, when the south end of a range to the westward measured 59° 30′ to N.W. peak, this gave the lat. of that part of the range, and at 44 miles came to N.W. peak.

∠'s at No. 8 △, or N.W. Peak.

Lat. by ✱'s N. and S. of zenith	32°	42′ N. ⊖
True bearing of flat-top mountain	S. 60	30 E. ☉
Compass „	S. 55	0 E.

For height of △. B. W. 210°·50. Aneroid	29°·00
Temp. of air	76·00

S. end of a lake to the east, and flat-top mountain ..	29° 30′
No. 5 △, and sharp peak No. 7 △	33·40
„ „ 6 △	24·05
No. 5 △, and point on sea-coast	113·00
„ t's of near range	{ 100·50 26·30

Travelled east (true) towards the lake.

At 15 miles came to the lake, out of which flowed the large river going to the south. Height by B. W. = 213·25.°

Considering the large size of this river, and having already fixed the extreme and a midway △, decided upon returning southward and examine the river on the route back.

∠'s at South side of Lake on West bank of River.*

No. 8 △ and No. 7	99°	10′
No. 7 △ and flat-top	32	00

∠'s at large Affluent from the Eastward.

No. 8 △, and No. 7 △	118°	40′
No. 7 △ „ flat-top	39	50

∠'s at large Affluent from the Westward.

Same objects	{ 146° 58	00′ 10

∠'s at large Affluent from the Eastward.

Same objects	{ 79° 94	00′ 30

∠'s at sharp Bend of River.

No. 7 △ due east (true)	° ⊖	′
No. 8 △, and No. 7 △	104	10
No. 7 △, and No. 6 △	67	30

Arrived at former △, river running into lake from the northward. Height by B. W. = 214·5°.

---

* These angles projected on a piece of *tracing-paper* will form a very good station-pointer, to determine this and the following △'s.

(B.)—GIVEN THE DEPARTURE, TO FIND THE DIFFERENCE OF LONGITUDE.

	0	1°	2°	3°	4°	5°	6°	7°	8°	9°
0°		1·0001	1·0006	1·0013	1·0026	1·0038	1·0055	1·0075	1·0098	1·0125
10	1·0154	1·0187	1·0224	1·0261	1·0306	1·0353	1·0403	1·0457	1·0514	1·0578
20	1·0642	1·0711	1·0785	1·0864	1·0946	1·1034	1·1126	1.1224	1·1326	1·1434
30	1·1547	1·1666	1·1792	1·1924	1·2062	1·2208	1·2361	1·2521	1·2690	1·2868
40	1·3054	1·3250	1·3456	1·3673	1·3902	1·4142	1·4395	1·4663	1·4945	1·5242
50	1·5557	1·5890	1·6242	1·6616	1·7013	1·7435	1·7883	1·8361	1·8871	1·9416
60	2·0000	2·0626	2·1301	2·2027	2·2812	2·3662	2·4586	2·5593	2·6695	2·7904
70	2·9238	3·0716	3·2361	3·4204	3·6280	3·8637	4·1337	4·4454	4·8097	5·2406
80	5·7587	6·3925	7·1856	8·2057	9·5664	11·475	14·334	19·108	28·653	57·307

USE OF THE TABLE.

Find in the Table the required parallel, the tens at the side and the units at the top: at their intersection will be found a quantity which, multiplied by the departure, gives the "diff. of longitude."

The departure from the meridian on the parallel of 34° was 25 miles—required the diff. of longitude.

25′ × 1·20 = 30′·00 the diff. of longitude.

In the parallel of 60° the departure was 30 miles.

30′ × 2 = 60 miles, or 1 degree.

In the parallel of 35° N. the route was N. 40 W., 37 miles' distance.

By Traverse Table, 40° course, 37 (Dis.) = 23·8 (Dep.) × 1·22 = 29·03 (Miles), diff. of longitude.

To measure the Number of Cubic Feet of Water conveyed by a River in each Second.

The data required are—the area of the river-section and the average velocity of the whole of the current. All that a traveller is likely to obtain, without special equipment, is the area of the river-section and the average velocity of the *surface* of the current, which differs from that of its entire body, owing to frictional retardation at the bottom.

To make the necessary measurements, choose a place where the river runs steadily in a straight and deep channel, and where a boat can be had. Prepare half-a-dozen floats, of dry bushes with paper flags, and be assured they will act. Post an assistant on the river-bank, at a measured distance (of about 100 yards) down stream, in face of a well-marked object. Row across stream in a straight line, keeping two objects on a line in order to maintain your course. Sound at regular intervals from shore to shore, fixing your position on each occasion, by a sextant-angle between your starting-place and your assistant's station, and throw the floats overboard, signalling to your assistant when you do so, that he may note the interval that elapses before they severally arrive opposite to him. Take an angle from the opposite shore, to give the breadth of the river.

To make the calculation approximately, protract the section of the river on a paper ruled to scale in square feet, and count the number of squares in the area of the section. Multiply this by the number of feet between you and the assistant, and divide by the number of seconds that the floats occupied, on an average, in reaching him.

Important rivers should always be measured above and below their confluence; for it settles the question of their relative sizes, and throws great light on the rainfall over their respective basins. The sectional area at the time of highest water, as shown by marks on the banks, ought also to be ascertained.

Hints on the Collection of Objects of Natural History.

By H. W. Bates, Assistant Secretary R.G.S.

Travellers who intend devoting themselves specially to Natural History will generally possess all the requisite information beforehand. It is to those whose objects or duties are of another nature, or who, whilst on a purely geographical land-exploration, wish to know the readiest means of collecting, preserving, and safely transmitting specimens they collect that the following hints are addressed:—

Outfit.—Double-barrel guns, with spare nipples; and a few common guns to lend to native hunters—especially if going to the interior of Tropical America.

Fine powder in canisters, and fine shot (Nos. 8 and 11), must be taken from England: coarse powder and shot can be had in any part. A good supply of the best caps.

Arsenical soap, a few pounds in tin cases; brushes of different sizes.*

Two or three scalpels, scissors (including a pair of short-bladed ones), forceps of different sizes, for inserting cotton into the necks of birds' skins; needles and thread.

A few small traps, with which to capture small (mostly nocturnal) mammals.

Strong landing-net for water mollusks, &c. Two stout insect *sweeping-nets.*

Cylindrical tin box for collecting plants, with shoulder-strap.

A few dozens of small and strong broad-mouthed bottles; and a couple of corked pocket-boxes.

Insect-pins: a few ounces each of Nos. 5, 14, and 11.

Stone jars for reptiles and fishes in spirit; to fit four in a box, with wooden partitions. If animals in spirit are to be collected largely, a supply of sheet-tin or zinc, with a pair of soldering-irons and a supply of soft solder, must be taken instead of stone jars. Cylindrical cases can be then made of any size required. By means of the soldering apparatus, also, empty powder-canisters and other tin vessels can be easily converted into receptacles for specimens.

A ream or two of botanical drying-paper, with boards of same size as the sheet, and leather straps.

A few gross of chip pill-boxes in nests.

A dozen corked store-boxes (about 14 inches by 11 inches, and 2½ inches deep,) fitted perpendicularly in a tin chest.

A few yards of india-rubber waterproof sheeting, as temporary covering to collections in wet weather, or in crossing rivers.

A set of carpenter's tools.

An outfit may be much lightened by having all the provisions and other consumable articles packed in square tin cases, and in

* Most of the articles of a Naturalist's outfit can be obtained, at a few days' notice, of Mr. S. Stevens, Natural History Agent, 24, Bloomsbury-street, W.C.

x 2

boxes and jars of such forms as may render them available for containing specimens. If the traveller is going to the humid regions of the Indian Archipelago, South-eastern Asia, or Tropical America, where excessive moisture, mildew, and ants, are great enemies to the naturalist, he should add to his outfit two drying-cages; for everything that is not put at once into spirits is liable to be destroyed before it is dry enough to be stowed away in boxes. They may be made of light wood, so arranged as to take to pieces and put together again readily; one, for birds, should be about 2 feet 6 inches long by 1 foot 6 inches high and 1 foot broad; the other, for insects and other small specimens, may be about one-third less. They should have folding doors in front, having panels of perforated zinc, and the backs wholly of the latter material; the sides fitted with racks to hold six or eight plain shelves, which, in the smaller cage, should be covered with cork or any soft wood that may be obtained in tropical countries. A strong ring fixed in the top of the cage, with a cord having a hook attached at the end by which to hang it in an airy place, will keep the contained specimens out of harm's way until they are quite dry, when they may be stowed away in close-fitting boxes. If this plan be not adopted, it will be almost impossible to preserve specimens in these countries.

Collecting.—The countries which are now the least known with regard to their Natural History, are New Guinea, and the large islands to the east of it, Northern Australia, the interior of Borneo, Thibet, and other parts of Central Asia, Equatorial Africa, and the eastern side of the Andes from east of Bogota to the south of Bolivia. In most of the better known countries the botany has been better investigated than the zoology, and in most countries there still remains much to be done in ascertaining the exact station, and the range, both vertical and horizontal, of known species. This leads us to one point, which cannot be too strongly insisted on, namely, that some means should be adopted by the traveller to record the exact locality of the specimens he collects. In the larger dried animals, this may be done by written tickets attached to the specimens; in pinned insects, a letter or number may be fixed on the pins of all specimens taken at one place and time—the mark to refer to a note-book. The initial letter, or first two or three letters of the locality, is perhaps the readiest plan; and when all the specimens taken at one place can be put into a separate box, one memorandum upon the box itself will be sufficient. Reptiles and fishes can have small parchment tickets attached to them before placing in spirits.

A traveller may be puzzled, in the midst of the profusion of animal and vegetable forms which he sees around him, to know what to secure and what to leave. Books can be of very little

service to him on a journey, and he had better at once abandon all idea of encumbering himself with them. A few days' study at the principal museums before he starts on his voyage may teach him a great deal, and the cultivation of a habit of close observation and minute comparison of the specimens he obtains will teach him a great deal more. As a general rule, all species which he may meet with for the first time far in the interior, should be preferred to those common near the civilized parts. He should strive to obtain as much variety as possible, and not fill his boxes and jars with quantities of specimens of one or a few species. But, as some of the rarest and most interesting species have great resemblance to others which may be more common, he should avail himself of every opportunity of comparing the objects side by side. In most tropical countries the species found in open and semi-cultivated places are much less interesting than those inhabiting the interior of the forests, and it generally happens that the few handsome kinds which attract the attention of the natives are species well known in European museums. In botany, a traveller, if obliged to restrict his collecting, might confine himself to those plants which are remarkable for their economical uses; always taking care to identify the flowers of the tree or shrub whose root, bark, leaves, wood, &c., are used by the natives, and preserving a few specimens of them. But, if he is the first to ascend any high mountain, he should make as general a collection of the flowering plants as possible, at the higher elevations. The same may be said of insects found on mountains, where they occur in very great diversity—on the shady and cold sides rather than on the sunny slopes—under stones, and about the roots of herbage especially near springs, on shrubs and low trees, and so forth; for upon a knowledge of the plants and insects of mountain ranges depend many curious questions in the geographical distribution of forms over the earth. In reptiles, the smaller Batrachia (frogs, salamanders, &c.,) should not be neglected, especially the extremely numerous family of tree-frogs; lizards may be caught generally with the insect sweeping-net; the arboreal species seen out of reach may be brought down with a charge of dust-shot. Snakes should be taken without injuring the head, which is the most important part of the body; a cleft stick may be used in securing them by the neck, and on reaching camp they may be dropped into the jars of spirits. As large a collection as possible should be made of the smaller fishes of inland lakes and unexplored rivers; Dr. Gunther, of the British Museum, has authorised me to say that a traveller cannot fail to make a large number of interesting discoveries if he collects a few specimens of the species he meets with in the lakes and rivers of the interior of any country.

It can scarcely be expected that specimens of the larger animals can be brought away by a geographical expedition, although some species are still desiderata in the large museums of Europe. Additional specimens of all genera, of which there are numerous closely-allied species (*e. g.* rhinoceros, antilope, equus, &c.) would be very welcome for the better discrimination of the species. If only portions can be obtained, skulls are to be preferred. In humid tropical regions entire skins cannot be dried in time to prevent decay, and it is necessary to place them, rolled up in small compass, in spirits. The smaller mammals, of which there remain many to reward the explorer in almost all extra-European countries, may be skinned, dried, and packed in boxes in the same manner as birds. The smaller birds shot on an excursion should be carried to camp in the game-bag, folded in paper, the wounds, mouth, and anus being first plugged with cotton. Powdered calcined gypsum will here be found very useful in absorbing blood from feathers, on account of the facility with which it can be afterwards cleared from the specimens. All plants, when gathered, are placed in the tin box which the traveller carries with him. Land and fresh-water shells may be carried home in a bag. All hard-bodied insects, such as beetles, ants, and so forth, should be placed, in collecting, in small bottles; each bottle having a piece of slightly-moistened rag placed within it, to prevent the insects from crowding and injuring each other. The hint previously given with regard to number of specimens must be repeated here. *Take as great a variety of species as possible.* The sweeping-net should be freely used (except in very wet weather) in sweeping and beating the herbage and lower trees. In collecting ants, it is necessary to open nests and secure the winged individuals of each species, which must be afterwards kept together with the wingless ones to secure the identification of the species. Bees and wasps may be caught in the net and then placed by means of small forceps in the collecting-bottle and afterwards killed in the same way as beetles and other hard-bodied insects. All soft-bodied insects should be killed on capture (by a slight pressure of the chest underneath the wings by thumb and finger) and then pinned in the pocket collecting-box. If the traveller has leisure and inclination for the pursuit, he may readily make a large and varied collection of these, and will do good service to science if he notes carefully the exact localities of his captures, altitude above the sea, nature of country, the sexes of the species (if detected), and information on habits. The delicate species should be handled very carefully and put away into the drying-cage immediately on return from an excursion. Spiders may be collected in bottles, aud afterwards killed and pinned in the same way as other insects. Crustacea (shrimps, crawfish, &c.) in rivers and pools may be col-

lected with the landing-net and afterwards well dried and pinned like hard-bodied insects, except when they are large in size, when their bodies must be opened and emptied of their contents.

Preserving and Packing.—Previous to skinning a small mammal or bird, make a note of the colour of its eyes and soft parts, and, if time admits, of the dimensions of its trunk and limbs. It facilitates skinning of birds to break, before commencing, the first bone of the wings a short distance above the joint, which causes the members to lie open when the specimen is laid on its back on the skinning-board. The animal should be laid with its tail towards the right hand of the operator, and the incision made from the breast-bone nearly to the anus. A blunt wooden style is useful in commencing the operation of separating the skin from the flesh. When the leg is reached, cut through the knee-joint and then clear the flesh from the shank as far as can be done, afterwards washing the bone slightly with arsenical soap, winding a thin strip of cotton round it and returning it to the skin. Repeat the process with the other leg, and then sever with the broad-bladed scissors the spine above the root of the tail. By carefully cutting into the flesh from above, the spine is finally severed without injuring the skin of the back, and it is then easy to continue the skinning up to the wings, when the bones are cut through at the place where they had previously been broken and the body finished as far as the commencement of the skull. A small piece of the skull is now cut away, together with the neck and body, and the brains and eyes scooped out, the inside washed with the soap, and clean cotton filled in, the eyes especially being made plump. In large-headed parrots, woodpeckers, and some other birds, the head cannot thus be cleaned ; an incision has, therefore, to be made either on one side or on the back of the neck, through which the back of the skull can be thrust a little away and then cleaned, the incision being afterwards closed by two or three stitches. The bones then remaining in each wing must be cleaned, which must be done without loosening the quill-feathers. It is much better to take out the flesh by making an incision on the outside of the skin along the flesh on the inner side of the wing. The inside of the skin must now be washed with the soap, and a neck of cotton (not too thick) inserted by means of the long narrow forceps, taking care to fix the end well inside the skull and withdrawing the empty forceps, without stretching the skin of the neck and thus distorting the shape of the bird. Skins need not be filled up with cotton or any other material, but laid, with the feathers smoothed down, on the boards of the drying-cage until they are ready to be packed in boxes. In very humid climates, like that of Tropical America, oxide of arsenic in powder is preferable to arsenical soap, on account of the skins drying quicker; but it cannot be recommended to the general traveller, owing to the danger attending its use.

In mammals the tail offers some difficulty to a beginner. To skin it, the root (after severing it from the spine) should be secured by a piece of strong twine, which should then be attached to a nail or beam; with two pieces of flat wood (one placed on each side of the naked root), held firmly by the hand and pulled downwards, the skin is made rapidly to give way generally to the tip. The tails of some animals, however, can be skinned only by incisions made down the middle from the outside. The larger mammal skins may be inverted, and, after washing with the soap, dried in the sun: as before remarked, it is often necessary to roll them up and preserve in spirit.

The skins of small mammals and birds, after they are *quite* dry, may be packed in boxes, which must be previously well washed inside with arsenical soap, lined with paper and again covered with a coating of the soap and well dried in the sun. This is the very best means of securing the specimens from the attacks of noxious insects, which so often, to the great disgust of the traveller, destroy what he has taken so much pains to procure. Where wood is scarce, as in the interior of Africa, boxes may be made of the skins of antelopes or other large animals by stretching them, when newly stripped from the animal, over a square framework of sticks, and sewing up the edges; after being dried in the sun they make excellent packing-cases.

With regard to reptiles and fishes, I cannot do better than quote the following remarks sent to me by Mr. Osbert Salvin, who collected these animals most successfully in Guatemala:—

"Almost any spirit will answer for this purpose, its fitness consisting in the amount of alcohol contained in it. In all cases it is best to procure the strongest possible, being less bulky, and water can always be obtained to reduce the strength to the requisite amount. When the spirit sold retail by natives is not sufficiently strong, by visiting the distillery the traveller can often obtain the first runnings (the strongest) of the still, which will be stronger than he requires undiluted. The spirit used should be reduced to about proof, and the traveller should always be provided with an alcoholometer. If this is not at hand, a little practice will enable him to ascertain the strength of the spirit from the rapidity with which the bubbles break when rising to the surface of a small quantity shaken in a bottle. When the spirit has been used this test is of no value. When animals or fish are first immersed, it will be found that the spirit becomes rapidly weaker. Large specimens absorb the alcohol very speedily. The rapidity with which this absorption takes place should be carefully watched, and in warm climates the liquid tested at least every twelve hours, and fresh spirit added to restore it to its original strength. In colder climates it is not requisite to watch so closely, but practice

will show what attention is necessary. It will be found that absorption of alcohol will be about proportionate to the rate of decomposition. Spirit should not be used too strong, as its effect is to contract the outer surface, and thus, closing the pores, prevent the alcohol from penetrating through to the inner parts of the specimen. *The principal point, then, is to watch that the strength of the spirit does not get below a certain point while the specimen is absorbing alcohol when first put in.* It will be found that after two or three days the spirit retains its strength: when this is the case, the specimen will be perfectly preserved. Spirit should not be thrown away, no matter how often used, so long as the traveller has a reserve of sufficient strength to bring it back to its requisite strength.

"In selecting specimens for immersion, regard must be had to the means at the traveller's disposal. Fish up to 9 inches long may be placed in spirit, with simply a slit cut to allow the spirit to enter to the entrails. With larger specimens, it is better to pass a long knife outside the ribs, so as to separate the muscles on each side of the vertebræ. It is also as well to remove as much food from the entrails as possible, taking care to leave all these in. The larger specimens can be skinned, leaving, however, the intestines in, and simply removing the flesh. Very large specimens preserved in this way absorb very little spirit. All half-digested food should be removed from snakes and animals. In spite of these precautions, specimens will often appear to be decomposing; but by more constant attention to re-strengthening the spirit they will, in most cases, be preserved.

"A case (copper is the best), with a top that can be unscrewed and refixed easily, should always be carried as a receptacle. The opening should be large enough to allow the hand to be inserted; this is to hold freshly-caught specimens. When they have become preserved, they can all be removed and soldered up in tin or zinc boxes. Zinc is best, as it does not corrode so easily. The traveller will find it very convenient to take lessons in soldering, and so make his own boxes. If he takes them ready made, they had best be arranged so as to fit one into another before they are filled. When moving about, all specimens should be wrapped in calico or linen or other rags to prevent their rubbing one against the other. This should also be done to the specimens in the copper case when a move is necessary, as well as to those finally packed for transmission to Europe. These last should have all the interstices between the specimens filled in with cotton-wool or rags. If a leak should occur in a case, specimens thus packed will still be maintained moist and will keep some time without much injury. Proof spirit should be used when the specimens are finally packed, but it is not necessary that it should be fresh."

Land and fresh-water shells, on reaching camp, should be placed in a basin of cold water to entice the animals out, and then, after draining off, killed by pouring boiling water over them. They may be cleared of flesh by means of a strong pin or penknife. The operculum or mouthpiece of all shells which possess it should be preserved and placed inside the empty shell. Each shell, when dry, should be wrapped in a piece of paper and the collection packed in a box, well padded with cotton or other dry and elastic material.

The insects collected on an excursion should be attended to immediately on arrival in camp. When leisure and space are limited, all the hard-bodied ones may be put in bottles of spirit; and each bottle, when nearly full, should be filled up to the cork with a piece of rag, to prevent injury from shaking. Many species, however, become stained by spirit, and it is far better in dry countries, such as Africa, Australia, and Central Asia, to preserve all the hard-bodied ones in a dry state in pill-boxes. They are killed, whilst in the collecting-bottles, by plunging, for a few moments, the bottom half of the bottles in hot water. An hour afterwards the contents are shaken out over blotting-paper and put into pill-boxes; the bottom of the boxes being padded with cotton, over which is placed a circular piece of blotting-paper. The open pill-boxes should then be placed in the drying-cage for a day or two and then filled up with more cotton, the layer of insects being first covered by a circular piece of paper.* The soft-bodied specimens, which are brought home pinned, should be stuck in the drying-cage until they are dry, and then be pinned very close together in the store-boxes. The store-boxes, both bottom and sides, should each have inside a coating of arsenical soap before they are corked, and as they become filled, one by one, should be washed outside with the soap and pasted all over with paper. Camphor and other preservatives are of little or no use in tropical climates. In some countries where the traveller may wish to make a collection of the butterfly fauna, the best way is to preserve all the specimens in little paper envelopes. He should be careful not to press the insects too flat, simply killing them by pressure underneath the breast, folding their wings carefully backwards and slipping them each into its envelope. In very humid tropical countries, such as the river valleys of Tropical America and the islands of the Eastern Archipelago, the plan of stowing away even hard-bodied insects in pill-boxes does not answer, on account of the mould with which they soon become covered. There are, then, only two methods that can be adopted: one preserving them at

* The only preservative needed is a diluted wash of arsenical soap inside the pill-boxes, which, as in all other cases when soap is used, must be well dried afterwards, before the boxes are filled.

once in spirits, the other pinning all those over a quarter of an inch long (running the pin through the right wing-case so as to come out beneath, between the second and third pair of legs); and gumming those of smaller size on small sheets of card, cut of uniform size so as to fit perpendicularly in racked boxes, like those used to contain microscopical slides, but larger. The cards may be a few inches square, and each may hold several scores of specimens, very lightly gummed down a short distance apart. After the cards are filled they should be well dried, and the box containing them washed outside with arsenical soap and pasted over with paper. All the pinned specimens should be placed to dry for a few days in the drying-cage, and afterwards pinned very close together in the corked store-boxes.

Plants are dried by pressure, by means of the boards and straps, between sheets of botanical drying-paper—the paper requiring to be changed three or four times. When dry, the specimens may be placed between sheets of old newspapers, together with the notes the traveller may have made upon them, each placed upon the object to which it refers. Bundles of papers containing plants are not of difficult carriage; but they require to be guarded against wet, especially in fording rivers and in rainy weather, and should be wrapped in skins or india-rubber sheeting until they can be safely packed in wooden boxes and despatched to Europe. Seeds may be collected when quite ripe and preserved in small packets of botanical paper, with a number written on referring to preserved specimens of the flowers. Dry fruits and capsules should be collected when in countries not previously explored by botanists, if the traveller has means of identifying the species to which they belong.

Fossils.—The collection of fossils and minerals (except in the case of the discovery of new localities for valuable metals) is not to be recommended to the traveller, if he is not a Geologist. Fossils from an unexplored country are of little use unless the nature and order of superposition of the strata in which they are found can be at the same time investigated. In the cases, however, of recent alluvial strata, or the supposed beds of ancient lakes, or deposits in caves, or raised sea-beaches containing shells or bones of vertebrate animals, the traveller will do well to bring away specimens if a good opportunity offers. If the plan of the expedition includes the collection of fossil remains, the traveller will, of course, provide himself with a proper geological outfit and obtain the necessary instructions before leaving Europe.

All collections made in tropical countries should be sent to Europe with the least possible delay, as they soon become deteriorated or spoilt unless great care be bestowed upon them. Dry skins of animals and birds may be packed in wooden cases simply

with sheets of paper to separate the skins. Shells and skulls should be provided with abundance of elastic padding, such as cotton. The boxes containing insects and crustacea should be placed in the middle of large boxes surrounded by an ample bed of hay or other light dry elastic material: if this last point be not carefully attended to, it will be doubtful whether such collections will sustain a voyage without much injury.

Travellers have excellent opportunities of observing the habits of animals in a state of nature, and these hints would be very deficient were not a few words said upon this subject. To know what to observe in the economy of animals is in itself an accomplishment which it would be unreasonable to expect the general traveller to possess, and without this he may bring home only insignificant details, contributing but little to our stock of knowledge. One general rule, however, may be kept always present to the mind, and this is, that anything concerning animals which bears upon the relations of species to their conditions of life is well worth observing and recording. Thus, it is important to note the various enemies which each species has to contend with, not only at one epoch in their lives, but at every stage from birth to death, and at different seasons and in different localities. The way in which the existence of enemies limits the range of a species should also be noticed. The inorganic influences which inimically affect species, especially intermittently (such as the occurrence of disastrous seasons), and which are likely to operate in limiting their ranges, are also important subjects of inquiry. The migrations of animals, and especially any facts about the irruption of species into districts previously uninhabited by them, are well worth recording. The food of each species should be noticed, and if any change of customary food is observed, owing to the failure of the supply, it should be carefully recorded. The use in nature of any peculiar physical conformation of animals, the object of ornamentation, and so forth, should also be investigated whenever opportunity occurs. Any facts relating to the interbreeding in a state of nature of allied varieties, or the converse—that is, the antipathy to intercrossing of allied varieties—would be extremely interesting. In short, the traveller should bear in mind that facts having a philosophical bearing are much more important than mere anecdotes about animals.

To observe the actions of the larger animals, a telescope or opera-glass will be necessary; and the traveller should bear in mind that if a microscope is ever needed in his journey, that by unscrewing the small tubes of the telescope a compound microscope of considerable power is produced.